भारतीय मानक

Indian Standard

IS 18058 : 2023

सुपरवाइजरी कंट्रोल और डाटा एक्वेज़िशन (स्काडा) सिस्टम डिस्प्ले के लिए दिशानिर्देश

Guidelines for Supervisory Control and Data Acquisition (SCADA) System Displays

ICS 33.200

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Power System Control and Associated Communications Sectional Committee, LITD 10

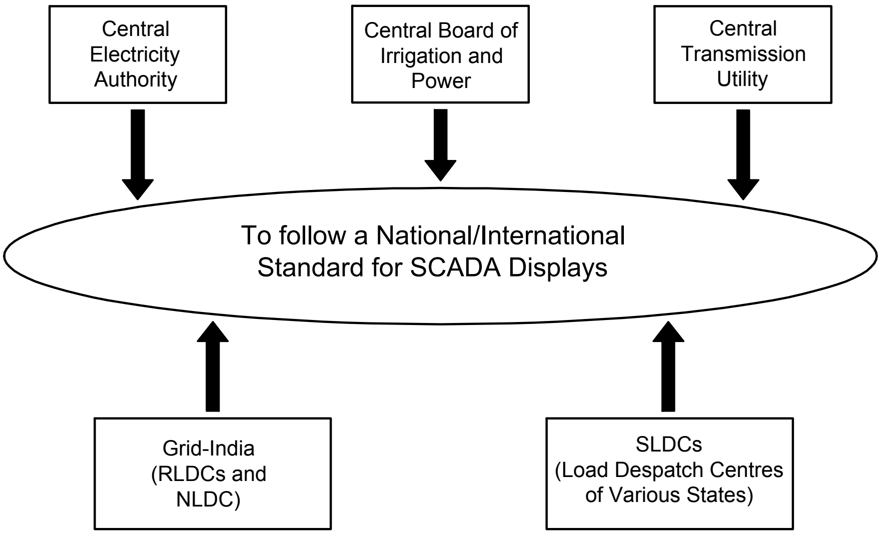
FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Power System Control and Associated Communications Sectional Committee and approved by the Electronics and Information Technology Division Council.

This Standard was prepared on the request of Grid Controller of India Limited (erstwhile Power System Operation Corporation Limited) and entails the guidelines regarding the Supervisory Control and Data Acquisition (SCADA) System Displays to be used in the context of Power System Applications.

Good visualization of SCADA power maps, map board displays, single line diagrams of substations, etc is an essential requirement to improve situational awareness for any grid operator. Existing SCADA system displays were developed about 10 years ago by State Load Despatch Centers (SLDC)/Regional Load Despatch Centers (RLDC)/National Load Despatch Centers (NLDC) at the time of implementation of SCADA projects under Unified Load Despatch and Communication (ULDC) scheme and were maintained and updated in an unconventional manner. The philosophy used in representation of the power system elements on SCADA displays was adopted on the basis of the requirements, preferences and instructions given to the person involved in making and updating these displays. Furthermore, locations of generating stations and sub-stations on the map were not based on its actual geographical position as per the corresponding latitude and longitude. As SCADA projects are periodically upgraded after a certain time-frame and displays are also to be recreated simultaneously, the standardization of SCADA display conventions across all RLDCs, SLDCs, Sub SLDCs, and DISCOMs also (as per applicability).

Various agencies in India, like Central Electricity Authority (CEA), Central Board of Irrigation and Power (CBIP), Central Transmission Utility (CTU), Grid Controller of India Limited (erstwhile Power System Operation Corporation Limited) and State Load Despatch Centers (SLDC), are involved in development, publishing and use of power maps which is mentioned in the following figure:


Central Electricity Authority
Central Board of Irrigation and Power
Central Transmission Utility
To follow a National/International Standard for SCADA Displays
Grid-India (RLDCs and NLDC)
SLDCs (Load Despatch Centres of Various States)

By adopting a nationwide common philosophy, all the agencies would be benefitted, and it would be easy to use and analyze Power Maps developed and published by other agencies.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Indian Standard

GUIDELINES FOR SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM DISPLAYS

1 SCOPE

This Indian Standard describes the display conventions to be used for development and maintenance of displays in supervisory control and data acquisition (SCADA) system for all RLDCs, SLDCs, Sub SLDCs, and DISCOMs also (as per applicability).

2 TERMINOLOGY AND DEFINITIONS

2.1 For the purpose of this standard the following definitions shall apply.

2.2 Display

Representation of data/information in visual forms such as text, table, graphical, infographics, etc in the user interface of SCADA System.

2.3 DWG Format

DWG (“drawing”) is a binary file format used for storing 2D and 3D design/drafting data. It is the native format for several CAD packages including AutoCAD, IntelliCAD, Caddie and by many other CAD applications.

2.4 Aspect Ratio

The ratio of the width to the height of an image or screen.

2.5 Substation

A substation is a part of an electrical generation, transmission, and distribution system. Substations transform voltage from high to low, or the reverse, or perform any of several other important functions.

2.6 Geographical Coordinate

A geographic coordinate system is a coordinate system that enables every location on Earth to be specified by a set of numbers, letters or symbols.

2.7 Single Line Diagram

In power engineering, a one-line diagram or single-line diagram is a simplified notation for representing a three-phase power system. The one-line diagram has its largest application in power flow studies.

2.8 Node

A node is any point on a circuit where the terminal of two or more circuit element meet in circuit diagrams, connections are ideal wires with zero resistance, so a node may consist of the entire section of wire between elements, not just a single point.

2.9 DXF Format

DXF is a file extension for a graphic image format typically used with AutoCAD (Computer Aided Design) software. DXF stands for drawing exchange format.

3 FORMAT AND SCALE

The power maps are used for reference in online system (SCADA/EMS) as well as for offline analysis. Therefore, power maps and displays in SCADA system shall be based on the geographical representation of state/regional/ national power system of India. The SCADA displays are generally not-to-scale but efforts shall be made to make it as close as possible to the actual relative positions and distancing between stations.

4 TEXT LANGUAGE, FONT AND LAYOUT

Power maps to be used for reference in online system (SCADA/EMS), shall have text displayed in Hindi as well as in English assigned to separate layers. The text size and font shall be such that they are clearly visible when maps are displayed on screen.

The text for 400 kV level and above stations shall be written in upper case while that of 220 kV and below shall be written in lower case with only the first alphabet in upper case. Different font size for different voltage levels could be adopted without affecting the clarity and readability of the text.

The general layout of the map shall be such that its height to width ratio is suitable to display on wide screen having an aspect ratio of 16 : 9. The aspect ratio of the screen can be modified by the utilities in case the display-monitor technology changes and some other aspect-ratio is adopted by the electronics hardware industry.

5 LEGENDS

The legends can be grouped in following four categories such as, borders; nodes; Interconnections and other elements. The graphical symbols for diagrams and colours to be used are listed as under.

5.1 Legend Category - A: Border (4 Types)

The pattern of the boundary shall be assigned as follows:

a) Round-Dot for Distribution Companies Boundary;
b) Dash-Dot for state boundary;
c) Dash for International boundary; and
d) Solid for Regional Boundary.

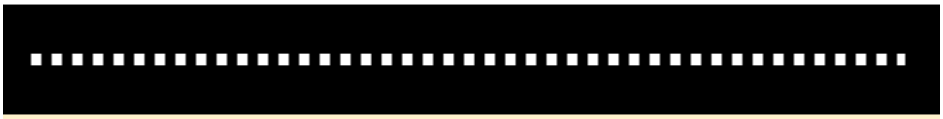
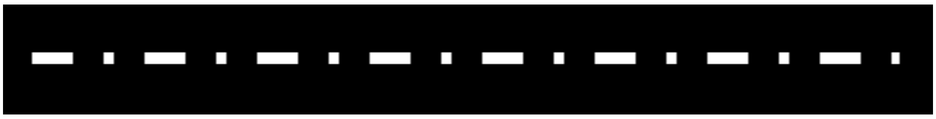
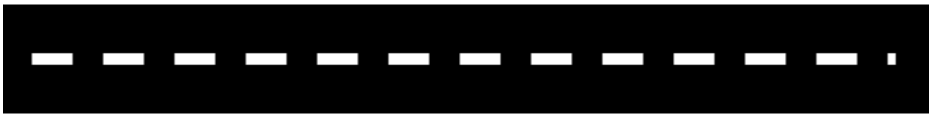
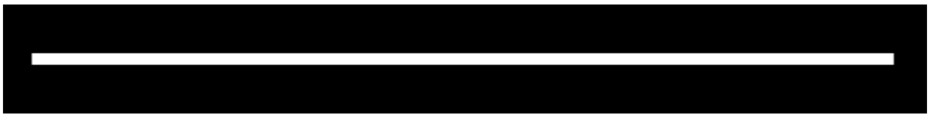
The colour of the boundary can be black or some other colour based on the proper visibility on different background for SCADA and printed maps.

Example:

In SCADA displays with black background, the boundary colour can be white as shown below:

Table 1 Boundaries Patterns

(*Clause* 5.1)

Sl No. (1)	**Description** (2)	**Illustration** (3)
i)	DISCOM boundary	 (Round-Dot)
ii)	State boundary	 (Dash-Dot pattern)
iii)	International boundary	 (Dash pattern)
iv)	Regional boundary	

5.2 Legend Category- B: Node (22 Types)

Table 2 Symbols for Nodes
(*Clause* 5.2)

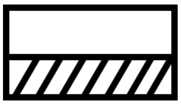
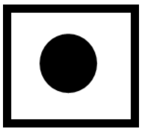
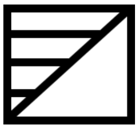
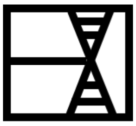
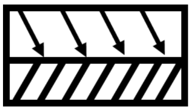
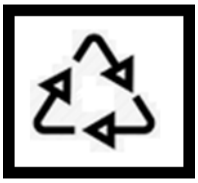
Sl No. (1)	**Description** (2)	**Illustration** (3)
i)	Thermal generating station (Coal/Gas/Lignite)	 (preferably to be shown in *White* colour with *Black* background)
ii)	Nuclear generating station	 (preferably to be shown in *White* colour with *Black* background)
iii)	Hydro generating station	 (preferably to be shown in *White* colour with *Black* background)
iv)	Wind generating station/farm	 (preferably to be shown in *White* colour with *Black* background)
v)	Solar generating station	 (preferably to be shown in *White* colour with *Black* background)
vi)	Other renewable power plants (excl. wind and solar)	 (preferably to be shown in *White* colour with *Black* background)

Table 2 (*Continued*)

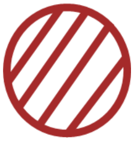
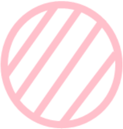
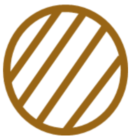
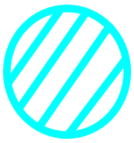
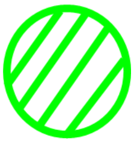
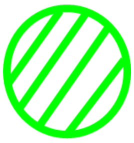
Sl No. (1)	**Description** (2)	**Illustration** (3)
vii)	11 kV substation	 Brown (hex #A52A2A; 165 Red, 42 Green and 42 Blue)
viii)	33 kV substation	 Pink (hex #FFC0CB; 255 Red, 192 Green and 203 Blue)
ix)	66 kV substation	 Golden Brown (hex #996515; 153 Red, 101 Green and 21 Blue)
x)	132 kV substation	 Cyan (hex #00FFFF; 0 Red, 255 Green and 255 Blue)
xi)	220 kV substation	 Lime Green (hex #00FF00; 0 Red, 255 Green and 0 Blue)
xii)	400 kV substation (*charged at 220 kV level*)	 Lime Green (hex #00FF00; 0 Red, 255 Green and 0 Blue)

Table 2 (*Continued*)

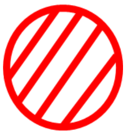
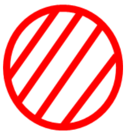
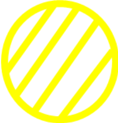
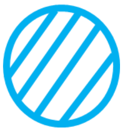
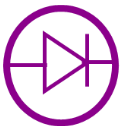
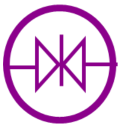
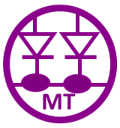
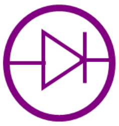
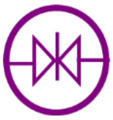
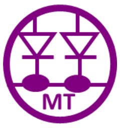
Sl No. (1)	Description (2)	Illustration (3)
xiii)	400 kV substation	 Red (hex #FF0000; 255 Red, 0 Green and 0 Blue)
xiv)	765 kV substation (*charged at 400kV level*)	 Red (hex #FF0000; 255 Red, 0 Green and 0 Blue)
xv)	765 kV substation	 Yellow (hex #FFFF00; 255 Red, 255 Green and 0 Blue)
xvi)	1200 kV substation	 Light Cold Blue (hex #00B0F0; 0 Red, 176 Green and 240 Blue)
xvii)	HVDC bi-pole rerminal station (± 500 kV)	 Magenta (hex #8B008B; 139 Red, 0 Green and 139 Blue)
xviii)	HVDC back-to-back terminal station (± 500 kV)	 Magenta (hex #8B008B; 139 Red, 0 Green and 139 Blue)

Table 2 (*Concluded*)

Sl No. (1)	**Description** (2)	**Illustration** (3)
xix)	Multi-terminal HVDC station (± 500 kV)	 Magenta (hex #8B008B; 139 Red, 0 Green and 139 Blue)
xx)	HVDC bi-pole terminal station (± 800 kV)	 Purple (hex #800080; 128 Red, 0 Green and 128 Blue)
xxi)	HVDC back-to-back terminal station (± 800kV)	 Purple (hex #800080; 128 Red, 0 Green and 128 Blue)
xxii)	Multi-terminal HVDC station (± 800 kV)	 Purple (hex #800080; 128 Red, 0 Green and 128

Transmission substation having multiple voltage levels shall be represented by concentric circles of the colour representing appropriate voltage level. The higher voltage level shall be represented by a circle of larger radius.

The size and placement of the legend of generating station shall be such that it fits with in the circle representing the voltage level of the transmission substation at which the generation is being evacuated.

The above representations are shown in example 1 and example 2 below:

Example 1:

> Suppose there is a 765/400/220/132 kV substation having interconnections at all the four voltage levels. The above substation along with its associated feeders shall be represented in the power map as under:

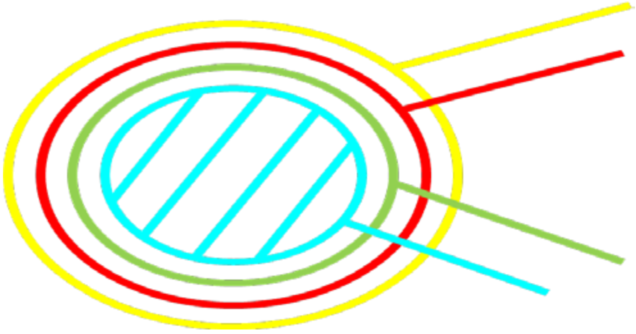


FIG. 1 SUBSTATION REPRESENTATION WITH MULTIPLE VOLTAGE LEVELS

Example 2:

Suppose there is a thermal (coal) generating station switched at 400 kV and this station also has a 765 kV level. Further assume that there is a +/- 500 kV HVDC connected at 400 kV. The above substation along with generating station and HVDC line shall be represented in the power map as under:

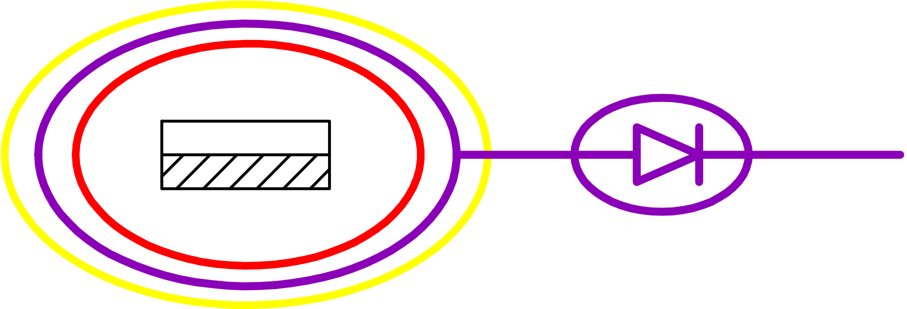


FIG. 2 GENERATING STATION REPRESENTATION WITH HVDC LINK

The placement of nodes should be accurate with regards to its geospatial coordinates. Exceptions may be taken only in case of certain nodes with coordinates too close to be represented with adequate clarity.

5.3 Legend Category - C: Interconnections (16 Types)

Table 3 Representation for Interconnections
(*Clause* 5.3)

Sl No. (1)	**Description** (2)	**Illustration** (3)
i)	Line at 11 kV voltage level	🟫 Brown (hex #A52A2A; 165 Red, 42 Green and 42 Blue)
ii)	Line at 33 kV voltage level	🟥 Pink (hex #FFC0CB; 255 Red, 192 Green and 203 Blue)
iii)	Line at 66 kV voltage level	🟫 Golden Brown (hex #996515; 153 Red, 101 Green and 21 Blue)
iv)	Line at 132 kV voltage level	🟦 Cyan (hex #00FFFF; 0 Red, 255 Green and 255 Blue)
v)	Line at 220 kV voltage level	🟩 Red (hex #FF0000; 255 Red, 0 Green and 0 Blue)
vi)	Line at 400 kV voltage level	🟥 Lime Green (hex #00FF00; 0 Red, 255 Green and 0 Blue)
vii)	Line at 765 kV voltage level	🟨 Yellow (hex #FFFF00; 255 Red, 255 Green and 0 Blue)
viii)	Line at 1 200 kV voltage level	🟦 Light Cold Blue (hex #00B0F0; 0 Red, 176 Green and 240 Blue)
ix)	Line at HVDC (± 500 kV)	🟪 Magenta (hex #8B008B; 139 Red, 0 Green and 139 Blue)
x)	Line at HVDC (± 800 kV)	🟪 Purple (hex #800080; 128 Red, 0 Green and 128 Blue)

Table 3 (*Continued*)

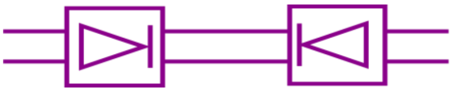
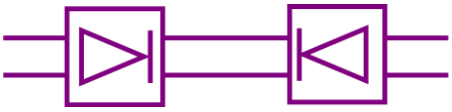
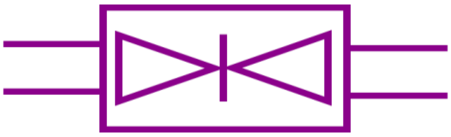
Sl No. (1)	**Description** (2)	**Illustration** (3)
xi)	± 500 kV HVDC bi-pole	 Magenta (hex #8B008B; 139 Red, 0 Green and 139 Blue)
xii)	± 800 kV HVDC bi-pole	 Purple (hex #800080; 128 Red, 0 Green and 128 Blue)
xiii)	± 500 kV HVDC back-to-back	 Magenta (hex #8B008B; 139 Red, 0 Green and 139 Blue)

Table 3 (*Continued*)

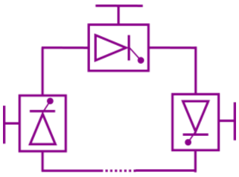
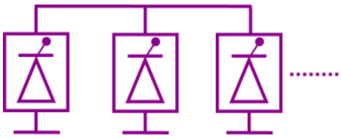
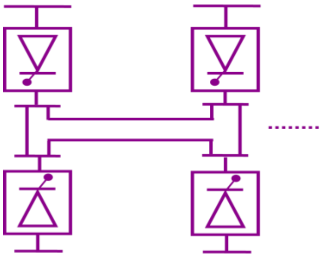
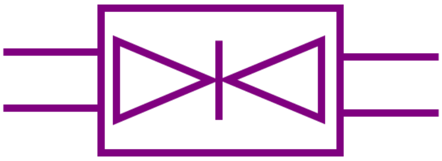
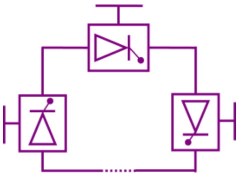
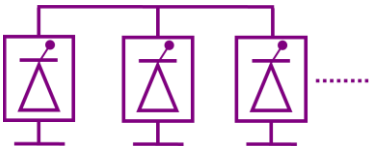
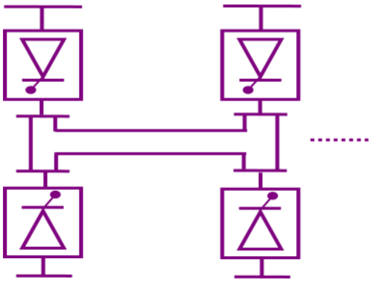
Sl No. (1)	**Description** (2)	**Illustration** (3)
xiv)	± 500 kV HVDC multi-terminal	**Series-Connected:**  **Parallel-Connected Radial:**  **Parallel-Connected Meshed:**  Magenta (hex #8B008B; 139 Red, 0 Green and 139 Blue)
xv)	± 800 kV HVDC back-to-back	 Purple (hex #800080; 128 Red, 0 Green and 128 Blue)

Table 3 (*Concluded*)

Sl No. (1)	Description (2)	Illustration (3)
xvi)	± 800 kV HVDC multi-terminal	**Series-Connected:**  **Parallel-Connected Radial:**  **Parallel-Connected Meshed:** 

The interconnections shall be represented by lines connecting two nodes. All the available interconnections (number of circuits and voltage level) between two nodes shall be represented distinctly. The thickness of the transmission line shall preferably be in increasing order of its voltage level. The transmission lines shall be drawn as per its geospatial coordinates, if possible. However, in the absence of the geospatial coordinates of the transmission line route, the representation on the map may be indicative only.

5.4 Legend Category- D: Other Power System Elements (28 Types)

Table 4 Symbols for Other Power System Elements

(*Clause* 5.4)

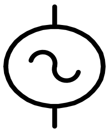
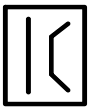
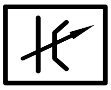
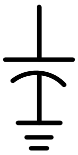
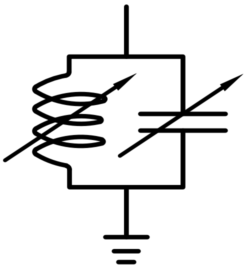
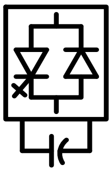
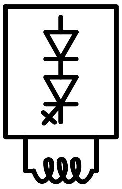
Sl No. (1)	**Description** (2)	**Symbols for Power Maps** (3)
i)	Generator	
ii)	Fixed Series Capacitor (FSC)	
iii)	Thyristor Controlled Series Reactor (TCSC)	
iv)	Shunt capacitor bank	
v)	Shunt Var Compensator (SVC)	
vi)	STATCOM (voltage source)	
vii)	STATCOM (current source)	

Table 4 (*Continued*)

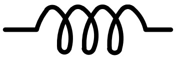
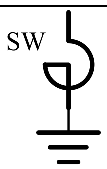
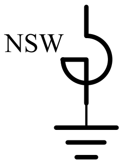
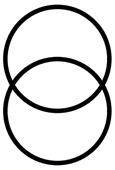
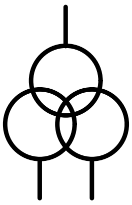
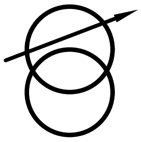
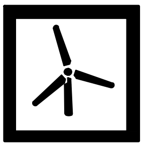
Sl No. (1)	**Description** (2)	**Symbols for Power Maps** (3)
viii)	Series reactor	
ix)	Switchable shunt reactor (bus reactor as well as line reactor)	
x)	Non-Switchable reactor (bus reactor as well as line reactor)	
xi)	Inter Connecting Transformer (ICT)	
xii)	Three winding transformer	
xiii)	Phase shifter transformer	
xiv)	Wind farm turbine	

Table 4 (*Continued*)

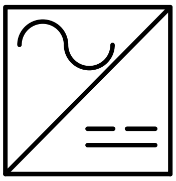
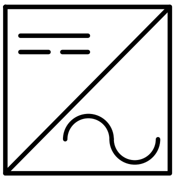
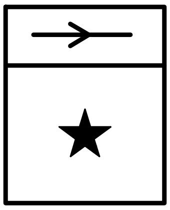
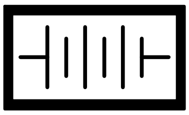
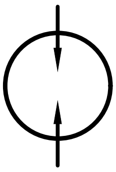
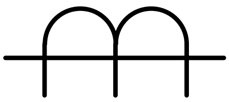
Sl No. (1)	**Description** (2)	**Symbols for Power Maps** (3)
xv)	Wind farm inverter	
xvi)	Solar farm inverter	
xvii)	Interface meters	
xviii)	Battery energy storage systems	
xix)	Lightning arrestor	
xx)	Current transformer	

Table 4 (*Continued*)

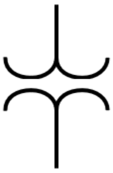
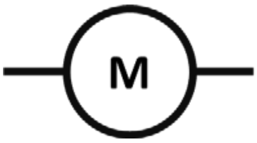
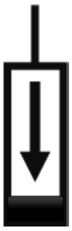
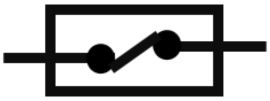
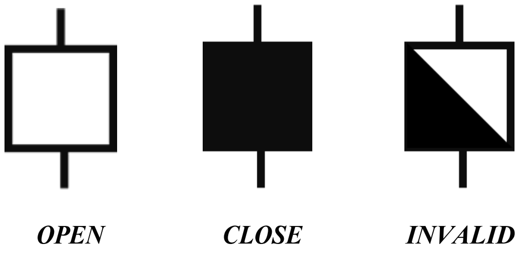
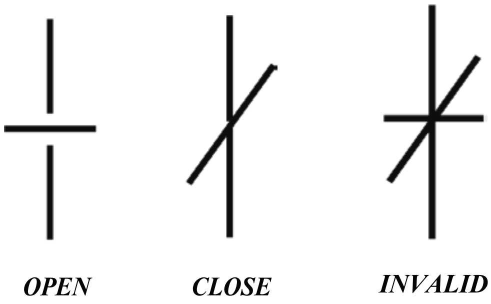
Sl No. (1)	**Description** (2)	**Symbols for Power Maps** (3)
xxi)	Potential transformer/Capacitor voltage transformer	
xxii)	Motor	
xxiii)	Load	
xxiv)	Fuse	
xxv)	Circuit breaker (Open, closed and invalid position)	
xxvi)	Isolator (Open, closed and invalid position)	

Table 4 (*Continued*)

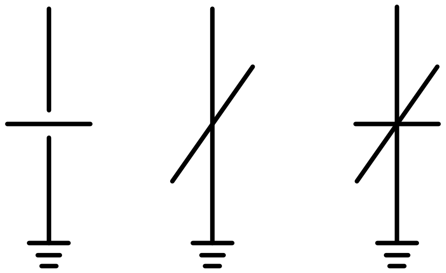
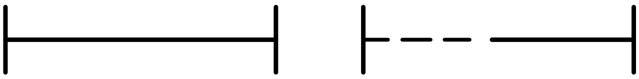
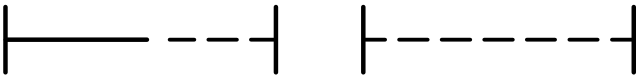
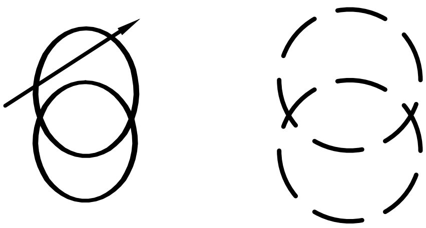
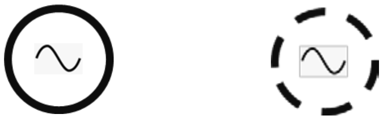
Sl No. (1)	**Description** (2)	**Symbols for Power Maps** (3)
xxvii)	Earth switch	 *OPEN* *CLOSE* *INVALID*
xxviii)	Energized/De-energized elements	**Transmission Line:**  Energized from both ends De-energized from one end  De-energized from other end De-energized from both ends **Transformer:**  Energized De-energized

Table 4 (*Concluded*)

Sl No. (1)	Description (2)	Symbols for Power Maps (3)
		Generator:  In Service Out of Service NOTE — Similar energization/de-energization effects can be assigned to other elements also as per requirements of the utilities.

The colour of the above equipment shall be same as the voltage level at which they are energized/installed. For instance, an interface meter on a 400 kV line shall be red in colour.

6 REPRESENTATION OF FUTURE ELEMENTS

The SCADA displays comprises of power system elements currently in service as well as the power system elements expected in future. These future elements can be represented with a similar legend but distinguishable in the form of square-dot pattern. For instance, the existing elements could be drawn with line style as "solid" while the future elements could be drawn with line style as "Square-Dotted".

7 COLOUR CODE

In choosing the shades vis-à-vis the voltage level it is recommended to choose colours closer to 'Red' for higher voltages and those closer to 'Violet' for lower voltages.

The colour code shall be as per Table 5.

Table 5 Colour Coding for Different Voltage Levels
(*Clause* 7)

Sl No. (1)	Voltage Level (2)	Colour Coding (3)
i)	800 kV HVDC	**Purple** **(hex#800080; 128 Red, 0 Green and 128 Blue)**
ii)	500 kV HVDC	**Magenta** **(hex#8B008B; 139 Red, 0 Green and 139 Blue)**
iii)	1 200 kV AC	**Light Cold Blue** **(hex#00B0F0; 0 Red, 176 Green and 240 Blue)**

Table 5 (*Concluded*)

Sl No. (1)	Voltage Level (2)	Colour Coding (3)
iv)	765 kV AC	**Yellow** **(hex#FFFF00; 255 Red, 255 Green and 0 Blue)**
v)	400 kV AC	**Red** **(hex#FF0000 ;255 Red, 0 Green and 0 Blue)**
vi)	220 kV AC (incl. 230 kV)	**Lime Green** **(hex#00FF00; 0 Red, 255 Green and 0 Blue)**
vii)	132 kV AC (incl. 110 kV)	**Cyan** **(hex#00FFFF; 0 Red, 255 Green and 255 Blue)**
viii)	66 kV AC	**Golden Brown** **(hex#996515;153 Red, 101 Green and 21 Blue)**
ix)	33 kV AC	**Pink** **(hex#FFC0CB;255 Red, 192 Green and 203 Blue)**
x)	11 kV AC	**Brown** **(hex # A52A2A; 165 Red, 42 Green and 42 Blue)**

Additional voltages not covered in the table, wherever necessary, shall be indicated by a colour so chosen making it distinguishable from the other colours appearing in the diagram. The background colour of the display shall preferably be black by default. If other colours are chosen for the display-background, then it shall be such as to render good contrast with the shades representing the voltage levels.

8 LAYER SYSTEM

The power system elements represented on the maps shall be displayed on separate layers to de-clutter the display and provide flexibility in the visualization. For instance, it should be possible to visualize the geographical position of the different kinds of substations or different kinds of generating station in the state/region/country. It shall also be possible to clearly visualize the transmission system on the basis of its voltage level and types (AC/DC). Suggested layer philosophy is mentioned in sub-clauses below. This is purely for illustration purpose and based on the requirement of operator, system performance etc various information can be displayed on separate layers.

8.1 Layer 0

In the geographical maps, the boundary representing international border, State border shall be distinguishable. Layer 0 shall be ON by default while the other layers shall be switchable by choice.

Table 6 Particulars of Layer 0
(*Clause* 8.1)

Sl No. (1)	**Layer** (2)	**Particulars** (3)
(i)	0 (or DEFAULT layer)	▪ Map border ▪ Logo ▪ Legend box ▪ Scale used in map ▪ Date on which map was updated ▪ Geographical boundaries ▪ Respective legend of the geographical boundary

8.2 Layer 1 to 25: Nodes

The contents of the legend box shall be linked to the respective layers in which the element is being displayed by the user that is, only those legends (along with its description) that have been chosen to be displayed by the user must be visible in the legend box.

The text associated with a power system element shall be linked to the respective layers in which the element is being displayed by the user.

Table 7 Particulars of Layer 1 to 25
(*Clause* 8.2)

Sl No.	**Layer**	**Particulars**
(1)	(2)	(3)
i)	1	Generating station (coal/gas/nuclear) switched at 11 kV level
ii)	2	Generating station (coal/gas/nuclear) switched at 33kV level
iii)	3	Generating station (coal/gas/nuclear) switched at 66 kV level
iv)	4	Generating station (coal/gas/nuclear) switched at 110 kV and 132 kV
v)	5	Generating station (coal/gas/nuclear) switched at 220 kV
vi)	6	Generating station (coal/gas/nuclear) switched at 400 kV level
vii)	7	Generating station (coal/gas/nuclear) switched at 765 kV level
viii)	8	Generating station (coal/gas/nuclear) switched at 1200 kV and above
ix)	9	Generating station (hydro/renewable) switched at 11 kV level
x)	10	Generating station (hydro/renewable) switched at 33 kV level
xi)	11	Generating station (hydro/renewable) switched at 66 kV level
xii)	12	Generating station (hydro/renewable) switched at 110 kV and 132 kV
xiii)	13	Generating station (hydro/renewable) switched at 220 kV
xiv)	14	Generating station (hydro/renewable) switched at 400 kV level
xv)	15	Generating station (hydro/renewable) switched at 765 kV level
xvi)	16	Generating station (hydro/renewable) switched at 1200 kV and above
xvii)	17	11 kV voltage level substation
xviii)	18	33 kV voltage level substation
xix)	19	66 kV voltage level substation

Table 7 (*Concluded*)

Sl No. (1)	Layer (2)	Particulars (3)
xx)	20	132 kV substation and 220 kV substation charged at 132 kV
xxi)	21	220 kV substation and 400 kV substation charged at 220 kV
xxii)	22	400 kV substation and 765 kV substation charged at 400 kV
xxiii)	23	765 kV voltage level substation
xxiv)	24	1 200 kV and above level substations
xxv)	25	± 500 kV and ± 800 kV HVDC terminal station

NOTE — In case of substations with multiple voltage levels, the highest voltage-level will be considered for depicting its layer.

8.3 Layer 26 to 43: Interconnections

The interconnections shall connect the nodes (that is, circle) of appropriate voltage level. For instance, a 220 kV line shall originate from a concentric circle representative of 220 kV and terminate at the appropriate concentric circle representative of 220 kV level.

The multiple interconnections between two nodes shall be distinguishable when all layers are switched ON.

Table 8 Particulars of Layer 26 to 43

(*Clause* 8.3)

Sl No.	Layer	Particulars
(1)	(2)	(3)
i)	26	11 kV line, 11 kV UG cable (*with circuit numbers*)
ii)	27	33 kV lines, 33 kV UG cable (*with circuit numbers*)
iii)	28	66 kV lines, 66 kV UG cable (*with circuit numbers*)
iv)	29	132 kV lines, 132 kV UG cable (*with circuit numbers*)
v)	30	220 kV line, 400 kV line charged at 220 kV, 220 kV UG cable (*with circuit*
vi)	31	400 kV line and 765 kV line charged at 400 kV (*with circuit numbers*)
vii)	32	765 kV line (*with circuit numbers*)
viii)	33	± 500 kV HVDC bi-pole, ± 800 kV HVDC bi-pole and HVDC back-to-back (*with circuit numbers*)
ix)	34	1 200 kV line (*with circuit numbers*)
x)	35	Line length (in km) of transmission lines at 11 kV level (*preferably with conductor-type symbol also*)
xi)	36	Line length (in km) of transmission lines at 33 kV level (*preferably with conductor-type symbol also*)
xii)	37	Line length (in km) of transmission lines at 66 kV level (*preferably with conductor-type symbol also*)
xiii)	38	Line Length (in km) of transmission lines at 132 kV level (*preferably with conductor-type symbol also*)
xiv)	39	Line length (in km) of transmission lines at 220 kV level (*preferably with conductor-type symbol also*)
xv)	40	Line length (in km) of transmission lines at 400 kV level (*preferably with conductor-type symbol also*)
xvi)	41	Line length (in km) of transmission lines at 765 kV level (*preferably with conductor-type symbol also*)
xvii)	42	Line length (in km) of transmission lines at ± 500 kV/± 800 kV HVDC level (*preferably with conductor-type symbol also*)
xviii)	43	Line length (in km) of transmission lines at 1 200 kV and above voltage level (*preferably with conductor-type symbol also*)

8.4 Layer 44 to 56: Other Elements

The power system elements associated with the substation and lines also should be displayed.

Table 9 Particulars of Layers 44 to 56
(*Clause* 8.4)

Sl No.	Layer	Particulars
(1)	(2)	(3)
i)	44	FSC, TCSC, Series reactor
ii)	45	SVC, STATCOM, Shunt capacitor bank, Switchable/Non switchable shunt
iii)	46	ICT, Phase shifter transformer
iv)	47	Interface meter
v)	48	Future nodes, interconnections and other elements of 11 kV voltage level.
vi)	49	Future nodes, interconnections and other elements of 33 kV voltage level
vii)	50	Future nodes, interconnections and other elements of 66 kV voltage level
viii)	51	Future nodes, interconnections and other elements of 110 kV and 132 kV voltage level
ix)	52	Future nodes, interconnections and other elements of 220 kV voltage level
x)	53	Future nodes, interconnections and other elements of 400 kV voltage level
xi)	54	Future nodes, interconnections and other elements of 765 kV voltage level
xii)	55	Future nodes, interconnections and other elements of 1 200 kV and above voltage level
xiii)	56	Future nodes, interconnections and other elements of ± 500 kV/± 800 kV HVDC level

NOTE — The elements specified in the "*Layer 44 to Layer 47*" above can be further segregated into layers depending upon different voltage levels if required by the utilities.

8.5 Layer 57 to 82: Hindi Text

Table 10 Particulars of Layer 57 to 82
(*Clause* 8.5)

Sl No.	Layer	Particulars
(1)	(2)	(3)
i)	57	Hindi text names of generating station (coal/gas/nuclear) at 11 kV voltage level
ii)	58	Hindi text names of generating station (coal/gas/nuclear) at 33 kV voltage level
iii)	59	Hindi text names of generating station (coal/gas/nuclear) at 66 kV voltage level
iv)	60	Hindi text names of generating station (coal/gas/nuclear) at 110 kV and 132 kV voltage level
v)	61	Hindi text names of generating station (coal/gas/nuclear) at 220 kV voltage level
vi)	62	Hindi text names of generating station (coal/gas/nuclear) at 400 kV voltage level
vii)	63	Hindi text names of generating station (coal/gas/nuclear) at 765 kV voltage level
viii)	64	Hindi text names of generating station (coal/gas/nuclear) at 1 200 kV and above voltage level
ix)	65	Hindi text names of generating station (hydro/renewable) at 11 kV voltage level
x)	66	Hindi text names of generating station (hydro/renewable) at 33 kV voltage level
xi)	67	Hindi text names of generating station (hydro/renewable) at 66 kV voltage level
xii)	68	Hindi text names of generating station (hydro/renewable) at 110 kV and 132 kV voltage level
xiii)	69	Hindi text names of generating station (hydro/renewable) at 220 kV voltage level
xiv)	70	Hindi text names of generating station (hydro/renewable) switched at 400 kV voltage level
xv)	71	Hindi text names of generating station (hydro/renewable) switched at 765 kV voltage level
xvi)	72	Hindi text names of generating station (hydro/renewable) switched at 1 200 kV voltage level
xvii)	73	Hindi text names of 765 kV and higher voltage level substations
xviii)	74	Hindi text names of 11 kV voltage level substation
xix)	75	Hindi text names of 33 kV voltage level substation
xx)	76	Hindi text names of 66 kV voltage level substation
xxi)	77	Hindi text names of 132 kV substation and 220 kV substation charged at 132 kV voltage level
xxii)	78	Hindi text names of 220 kV substation and 400 kV substation charged at 220 kV voltage level
xxiii)	79	Hindi text names of 400 kV substation and 765 kV substation charged at 400 kV voltage level
xxiv)	80	Hindi text names of 765 kV voltage level substation
xxv)	81	Hindi text names of 1 200 kV and above level substations
xxvi)	82	Hindi text names of ± 500 kV and ± 800 kV HVDC terminal station

8.6 Layer 83 to 91: Dynamic Data

Table 11 Particulars of Layer 83 to 91
(*Clause* 8.6)

Sl No. (1)	Layer (2)	Particulars (3)
i)	83	1 200 kV voltage level data
ii)	84	HVDC level (± 800 kV, ± 500 kV) data
iii)	85	765 kV voltage level data

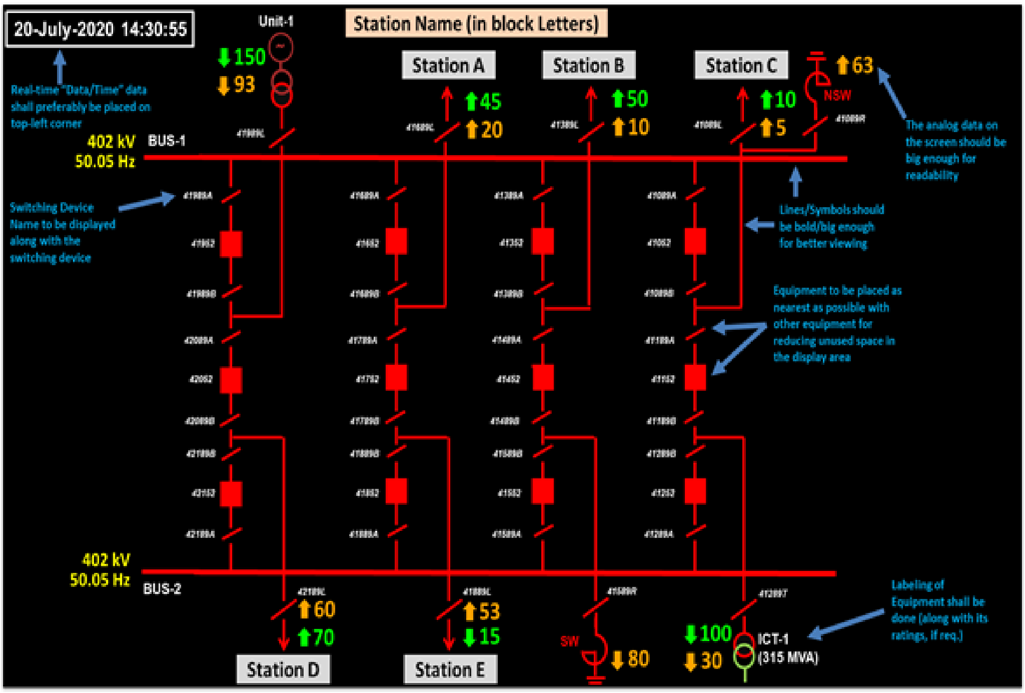
Table 11 (*Concluded*)

Sl No. (1)	Layer (2)	Particulars (3)
iv)	86	400 kV voltage level data
v)	87	220 kV and 230 kV voltage level data
vi)	88	132 kV and 110 kV voltage level data
vii)	89	66 kV voltage level data
viii)	90	33 kV voltage level data
ix)	91	11 kv voltage data

Segregation of various forms of data in different layers helps in customized selection of combination of layers to be made visible at any particular time based on the changing requirements of the operators in control rooms. The user may have to switch ON multiple layers to visualize the maps with desired level of detail and clarity.

9 LAYOUT OF SINGLE LINE DIAGRAM OF A SUBSTATION

The Single Line Diagrams (SLD) which need to be made for each substation shall be made in the manner shown below:



Real-time "Data/Time" data shall preferably be placed on top-left corner

Switching Device Name to be displayed along with the switching device

The analog data on the screen should be big enough for readability

Lines/Symbols should be bold/big enough for better viewing

Equipment to be placed as nearest as possible with other equipment for reducing unused space in the display area

Labeling of Equipment shall be done (along with its ratings, if req.)

FIG. 3 SAMPLE SINGLE LINE DIAGRAM REPRESENTATION

A substation contains all major power equipment such as line ends, transformers, generating units, reactors, circuit breakers, isolators, buses and all the telemetered instruments. Each line end shall be shown as a line with arrow going outside the substation and a hyperlink shall be provided along with the arrow which on clicking opens a display of the far end substation

In the Single Line Diagrams (SLD) of the substations, text such as "MW", "MVAR", "KV", "HZ", etc shall be displayed along with the corresponding analog data if there is no space constraint.

In addition to above, the following details may be displayed in the Single-Line Diagram as per requirements of the utilities:

a) Ratings of equipment (such as MVA of ICT, installed capacity of generators, MVA ratings of reactors);
b) Weather parameters (such as temperature, wind-speed, wind direction, luminosity and other available telemetry);
c) RGMO status for generating stations;
d) Water reservoir level in case of Hydro power stations;
e) Contact details of the substation (preferably on the top-right portion of the SLD);
f) Protocol of reporting of data to the control centers; and
g) Communication media for reporting of data to the control centers (such as optical fiber, VSAT, PLCC, etc).

10 COLOUR CODING OF THE STATIC DATA TO BE PLACED ON THE DISPLAYS IN SCADA SYSYTEMS

In general, all the static data such as name of substations, headings of tables, time-date-day, contact details, equipment parameters, etc shall be displayed in white colour on black background in English, Hindi and other local languages as required by the utilities. In case of background colour other than black, some other suitable colour can be adopted for representing the static data.

11 COLOUR CODING OF THE DYNAMIC DATA TO BE PLACED ON THE DISPLAYS IN SCADA SYSTEMS

In various load despatch centres, customized displays are made and used in SCADA/EMS system and huge amount of real-time data is placed on it for visualization. This comprises the dynamic data and shall be represented as per Table 12.

Table 12 Colour Coding for Dynamic Data

Sl No. (1)	Description (2)	Colour Coding for Dynamic Data (3)
i)	Analog MW	➡ 9999 ⬆ 9999 ⬅ 9999 ⬇ 9999 Lime Green (hex #00FF00; 0 Red, 255 Green and 0 Blue) NOTE — In case of Phase-wise MW available from site, a subscript such as “R-Ph”, “YPh” and “B-Ph” can be shown along with the data for clarity
ii)	Analog MVAR	➡ 9999 ⬆ 9999 ⬅ 9999 ⬇ 9999 Orange (hex #FFA500; 128 Red, 0 Green and 128 Blue) NOTE — In case of Phase-wise MVAR available from site, a subscript “R-Ph”, “Y-Ph” and “B-Ph” can be shown along with the data for clarity.
iii)	Analog current	➡ 9999 ⬆ 9999 ⬅ 9999 ⬇ 9999 Light Blue (hex #9DC3E6; 157 Red, 195 Green and 230 Blue) NOTE — In case of Phase-wise current available from site, a subscript “R-Ph”, “Y-Ph” and “B-Ph” can be shown along with the data for clarity.
iv)	Analog kV	9999 Yellow (hex #FFFF00; 255 Red, 255 Green and 0 Blue) NOTE — In case of Phase-wise kV available from site, a subscript “R-Ph”, “Y-Ph” and “BPh” can be shown along with the data for clarity.
v)	Analog Hz	99.99 Yellow (hex #FFFF00; 255 Red, 255 Green and 0 Blue)
vi)	Analog generation	9999 Coral (hex #FF7F50; 255 Red, 127 Green and 80 Blue)
vii)	Analog angle	999◆ Golden (hex #FFD966; 255 Red, 217 Green and 102 Blue) NOTE — In case of Phase-wise angle available from site, a subscript “R-Ph”, “Y-Ph” and “B-Ph” can be shown along with the data for clarity.

Table 12 (*Concluded*)

Sl No. (1)	Description (2)	Colour Coding for Dynamic Data (3)
viii)	Transformer tap status	99 Peach (hex #FFDAB9; 255 Red, 218 Green and 185 Blue)
ix)	Estimated MW	➡ 9999 ⬆ 9999 ⬅ 9999 ⬇ 9999 Cyan (hex #00FFFF; 0 Red, 255 Green and 255 Blue)
x)	Estimated MVAR	➡ 9999 ⬆ 9999 ⬅ 9999 ⬇ 9999 Magenta (hex #8B008B; 139 Red, 0 Green and 139 Blue)
xi)	Estimated kV	9999 Coral (hex #EE82EE; 238 Red, 130 Green and 238 Blue)
xii)	Estimated angle	999◆ Dark Gold (hex #FFA500; 255 Red, 165 Green and 0 Blue)
xiii)	Estimated transformer tap status	99 Moccasin (hex #FFE4B5; 255 Red, 228 Green and 181 Blue)
xiv)	Weather parameters	999 Dark Blue (hex#0070C0; 0 Red, 112 Green and 192 Blue) NOTE — Certain subscripts such as "Deg.Cel.", "Kmph", etc, can be associated with weather for clarity.

The colour, size and other attributes related to alarms shall be as per Table 13. The effects of limit violations on the lines at some voltage levels are mentioned in Table 13. Similar approach can be adopted for other voltage levels also.

Table 13 Attribute Changes of Interconnections in Case of Alarms

Sl No. (1)	Desciption (2)	Alarm Condition (3)	Illustration (4)
i)	Line at 220kV voltage level	No Alarm	🟩 Width: 2, Blinking: No
		Alarm Limit 1	🟩 Width: 4, Blinking: No
		Alarm Limit 2	🟩 Width: 5: Blinking: Yes
		Alarm Limit 3	🟩 Width: 6, Blinking: Yes
ii)	Line at 400kV voltage level	No Alarm	🟥 Width: 2, Blinking: No
		Alarm Limit 1	🟥 Width: 4, Blinking: No
		Alarm Limit 2	🟥 Width: 5: Blinking: Yes
		Alarm Limit 3	🟥 Width: 6, Blinking: Yes
iii)	Line at 765 kV voltage level	No Alarm	🟨 Width: 2, Blinking: NO
		Alarm Limit 1	🟨 Width: 4, Blinking: No
		Alarm Limit 2	🟨 Width: 5: Blinking: Yes
		Alarm Limit 3	🟨 Width: 6, Blinking: Yes
iv)	Line at 1200kV voltage level	No Alarm	🟦 Width: 2, Blinking: No
		Alarm Limit 1	🟦 Width: 4, Blinking: No
		Alarm Limit 2	🟦 Width: 5: Blinking: Yes
		Alarm Limit 3	🟦 Width: 6, Blinking: Yes

NOTE — In case the thickness of the transmission lines put in displays are considered in increasing order of its voltage level, then the above-mentioned "*widths*"can be suitably modified in the same trend.

As per the current practice only three limits are defined for each analog in SCADA system; whereas in case of more than 3 limits the concerned utilities can decide on the additional attributes for depicting limit violations.

Moreover, the limits to configure different colour effects in contour-maps can be different from the above-mentioned limits; hence, it may not be restricted to these limits in case of making contour-maps and other applications.

For Analog, Alarm Limit 1 signifies high voltage limit and Alarm Limit 2 signifies low voltage limit. Such effects corresponding to Alarms needs to be implemented in the Single Line Diagrams of substations as given in Table 14 below:

Table 14 Attributes Changes of Dynamic Data in Case of Alarms
(*Clause* 11)

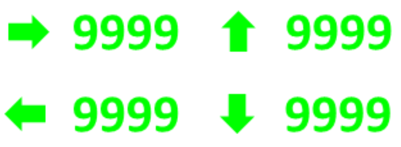
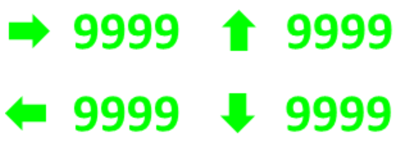
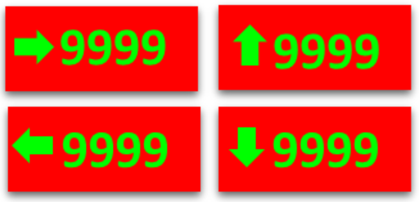
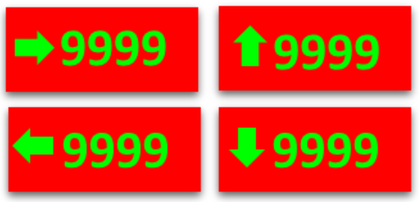
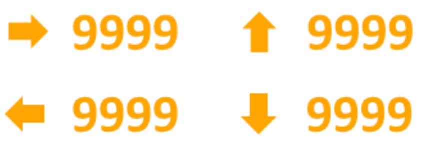
Sl No. (1)	**Description** (2)	**Alarm Condition** (3)	**Illustration** (4)
i)	Analog MW	No Alarm	 Blinking: No, Background: No
		Alarm Limit 1	 Blinking: Yes, Background: No
		Alarm Limit 2	 Blinking: No, Background box: Yes, Background box blinking: No
		Alarm Limit 3	 Blinking: No, Background box: Yes, Background box blinking: Yes
ii)	Analog MVAR	No Alarm	 Blinking: No, Background: No

Table 14 (*Continued*)

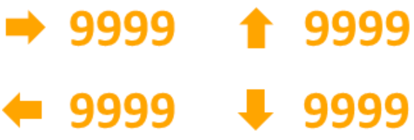
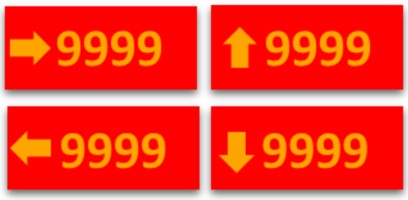
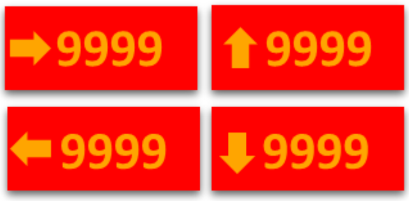
Sl No. (1)	Description (2)	Alarm Condition (3)	Illustration (4)
		Alarm Limit 1	 Blinking: Yes, Background: No
		Alarm Limit 2	 Blinking: No, Background box: Yes, Background box blinking: No
		Alarm Limit 3	 Blinking: No, Background box: Yes, Background box blinking: Yes

Table 14 (*Concluded*)

Sl No. (1)	**Description** (2)	**Alarm Condition** (3)	**Illustration** (4)
iii)	Analog kV	No Alarm	9999
		Alarm Limit 1 (High)	9999 Blinking: No, Background box: Blue, Background box blinking: No
		Alarm Limit 2 (Low)	9999 Blinking: No, Background box: Red, Background box blinking: No
iv)	Analog Hz	No Alarm	99.99 Blinking: No, Background: No
		Alarm Limit 1 (High)	99.99 Blinking: No, Background box: Blue, Background box blinking: No
		Alarm Limit 2 (Low)	99.99 Blinking: No, Background box: Red, Background box blinking: No

NOTE — Similar patterns can be followed for other data such as current, OLTC, angles, etc also as required by the utilities.

12 QUALITY FLAG

Various flags which are to be displayed along with the real-time data also need to be standardized and shall follow the convention as mentioned in Table 15 below:

Table 15 Quality Flags for Various Cases of Data Status
(*Clause* 12)

Sl No. (1)	**Description** (2)	**Quality Flags Representation** (3)
i)	Uninitialized	U
ii)	Old	S
iii)	Telemetry failure	S
iv)	Bad	S
v)	Over range	S
vi)	Unreasonable	P
vii)	Remote suspect	S
viii)	Anomalous	A
ix)	Manually replaced	M
x)	Remote replaced	R
xi)	State estimator replaced	E
xii)	Generalized calculation replaced	C
xiii)	Not in service	N
xiv)	Alarm inhibit	I
xv)	Alternate data source	@
xvi)	Object under testing	T

ANNEX A

(*Foreword*)

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